Attainability of the $PM_{2.5}$ Standard for Selected Tennessee Valley Cities

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Summary

Data on fine particle mass ($PM_{2.5}$) concentrations collected since 1997 suggest that several cities in the Tennessee Valley are likely not going to meet the annual $PM_{2.5}$ standard of 15 μg m^{-3}. Data for three cities—Nashville, Chattanooga and Knoxville—are used in this study along with data for a rural site (Lawrence County) in south-central Tennessee. An analysis of the $PM_{2.5}$ concentrations for these sites found that the relative ranking of their annual and summer averages are the same, with the rural site falling just below the annual standard and the cities falling well above. The primary difference between the urban and rural sites is in the number of days for which $PM_{2.5}$ is high (i.e., the upper tail of the distribution). Reduce the size of this tail, or the number of days with averages falling above 15 μg m^{-3}, and the annual average will decline accordingly. Compared to the rural site, Knoxville, Nashville and Chattanooga have roughly 60, 80 and 100 more days per year, respectively, when $PM_{2.5}$>15 μg m^{-3}. Summer levels of $PM_{2.5}$ are higher, on average, than in other seasons.

Model Results – A previous modeling study of air quality benefits for ambient $PM_{2.5}$ from pollutant emission reductions showed that the largest absolute and relative benefits probably occur during periods when particle levels are highest. This implies that a reduction in, for example, annual SO_2 emissions would provide the largest percentage reduction in sulfate and $PM_{2.5}$ concentrations during summer. A first-order approximation can be made that any modeled reduction in the number of summer days when $PM_{2.5}$>15 μg m^{-3} would, when extrapolated to an entire year, overestimate the annual benefit. The exact impact on annual mean $PM_{2.5}$ from a reduction in the number of 15+ μg m^{-3} days cannot be predicted without assuming that any benefits that occur do so across all days in the upper tail of the distribution of daily values. In other words, the portion of the cumulative distribution above 15 μg m^{-3} is assumed to move more or less uniformly toward the lower end of the distribution. In reality, it is not unreasonable to expect the higher concentration days to show even greater improvement than on days producing lower concentrations. This would have an even greater impact on the annual average than the previous "uniform reduction" assumption implies.

An estimate was made, using these assumptions, of the likelihood that the annual $PM_{2.5}$ standard could be met in the three Tennessee cities from any amount of SO_2 emission reductions at Tennessee Valley Authority (TVA) coal-fired boilers. A set of three summer episodes was modeled and results extrapolated to the entire year (recognizing the conservatism of such an approach as previously outlined). The meteorological and emissions data used for this exercise, as well as the model itself, were taken from recent air quality modeling work done by the Southern Appalachian Mountains Initiative (SAMI). Modeling results from each of the 24 days of the three summer episodes were taken at face value and no attempt was made to estimate a seasonal or annual weighting function for any individual day.

The time periods modeled were 24-29 June 1992, 3-11 August 1993 and 11-19 July 1995. A comparison of 1992-1995 and 1997-1999 $PM_{2.5}$ data from PSD Class 1 areas found that rural levels of $PM_{2.5}$ representing the earlier period were virtually indistinguishable from those in 1997-1999 when the first urban data were collected. Therefore, the Lawrence County data are a convenient representation of conditions for both periods. In addition, there is no information on earlier levels of urban $PM_{2.5}$. The assumption for this analysis is that the Tennessee urban levels have changed little between the 1992-1995 and 1997-1999 periods. This allows use of the SAMI model episodes for a rough estimate of the impact of future emission scenarios on "present day" urban $PM_{2.5}$ levels.

SAMI modeling results for the base periods (using actual emissions to the extent possible) were compared with results for simulations using emissions projected to 2010. A second emissions scenario was modeled to examine the impact of TVA emissions by totally removing those emissions. This is referred to as the "Modeled 2010/Zero TVA" scenario.

Model results extrapolated to a year suggest that the greatest reduction by 2010 in $PM_{2.5}$ will occur at rural sites like Lawrence County. Much smaller changes are projected for the urban areas, and they are all upward. The reason for this is that sulfate composes a larger fraction of $PM_{2.5}$ mass at the rural sites than at urban sites. Hence, large reductions in sulfate

will mostly benefit rural sites. Urban sites that are projected to grow (a situation that is true for all the Tennessee cities considered here) show small increases in $PM_{2.5}$ despite regional sulfate reductions. This is attributable to increases in other $PM_{2.5}$ components, especially organic carbon.

Nashville is projected to need a decrease of roughly 80 in the number of 15+ $\mu g\ m^{-3}$ days to comply with the annual $PM_{2.5}$ standard. Modeling suggests that the emission changes projected for 2010 will not relieve the situation. Instead, the number of annual high days will actually increase by up to 9. In the extreme, removing all TVA fossil plant SO_2 emissions would, according to the model, reduce sulfate sufficiently to decrease the number of high $PM_{2.5}$ days by as much as 50 in Nashville. However, this is still far short of the estimated 80 days needed. The situation is even more bleak for Knoxville and Chattanooga. Like Nashville, both cities are projected to experience worsening $PM_{2.5}$ levels by 2010. The complete absence of TVA SO_2 emissions would still not prevent an increase in Knoxville of the number of high $PM_{2.5}$ days, and would not decrease this number anywhere near the projected 100 days needed for Chattanooga.

<u>Conclusions</u> – A simple methodology for estimating the ability of a site to comply with the annual $PM_{2.5}$ standard was developed using recent model results from the SAMI integrated air quality assessment and recent $PM_{2.5}$ measurements. More sophisticated techniques for making these estimates are possible. However, by way of a conservative analysis it seems likely that the cities of Nashville, Knoxville and Chattanooga will not comply with the annual standard in 2010. In addition, TVA Title IV-compliant fossil plant SO_2 emissions are not, in themselves, large enough to push the cities into non-compliance with the annual standard. Other sources in and upwind of these cities appear capable of pushing the urban levels well above the annual standard, and projected growth in these emissions is expected to exacerbate the problem in all of these Tennessee Valley cities by 2010.